Highlights

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SPECIAL REPORT

Research Programs - Advanced Research Projects Agency

Here, for guidance and reference, is one of the first reports on research programs sponsored by the Advanced Research Projects Agency (ARPA) -- the Pentagon's agency for management and funding of military space technology, ballistic missile defense and solid propellant technology. These studies, as summarized by ARPA Chief Scientist George P. Sutton, support projects reported in detail in previous issues of SCIENCE TRENDS.

Fundamental Research

Fundamental or basic research has goals which are beyond the limits of human knowledge. Here we attempt to investigate physical behavior and physical phenomena of a fundamental nature which are in a general way related to the basic projects which face our organization. Here our hope and expectation is to discover new knowledge, new concepts, and new principles which will, in turn, give us better understanding of what is really going on in areas of probable interest to us. This understanding of the physics and the basic sciences subsequently permits better methods and techniques for designing vastly improved equipment.

We are setting up a program at the University of Chicago and we have programs in-being at Ohio State University, Vanderbilt, and the University of Wisconsin on fundamental high temperature thermo-chemistry. Some of these are theoretical studies into the fundamental properties of chemical formulations suitable for rocket propellants. They yield theoretical values of these properties and the performance that can be obtained with hypothetical new formulations. They also give us clues as to the promise of potentially new chemical compounds. Some of these projects are of an experimental nature and are intended to produce new formulations and to measure some fundamental properties of new synthetically formed chemicals suitable for rocket propulsion.

Another example is an investigation of the interactions of phonons with phonons, and "holes" with electrons. This work is related to the transmission of energy through various materials, particularly semiconductors, and has application to thermoelectric devices. These devices can convert heat from the sun (or from a nuclear reactor) into electrical energy for various power applications. The work now in process is decidedly of a basic nature and is concerned with the interactions of various fundamental particles within the materials structure.

This effort may very well yield a new understanding of certain materials and reap benefits in transistor technology, semiconductors and other areas.

We are also sponsoring research on photo-sensitive materials for better photo-voltaic cells which again will eventually be used for converting the sun's energy into a usable form. We are working on novel materials such as certain cheap organic materials for this purpose. We also are sponsoring work in special materials, for thermal-electric purposes, which are capable of withstanding very high ambient temperatures and give us the potential capability to design machinery with improved thermal efficiencies.

We also want to learn more about the upper atmosphere. We have a number of fundamental studies to investigate some of the atomic collission processes that go on at very high altitudes and to determine the interaction of electrons with various atomic species. We are probing the ion densities of the upper atmosphere.

The exact application of any knowledge that we may gain is not yet certain, but it may be useful in understanding some of the propagation of electromagnetic waves, some of the physical phenomena of the upper regions of the atmosphere and the interaction of the upper atmosphere with space vehicles.

In ballistic missile defense programs, there is the problem of detecting an incoming enemy warhead well before it reaches its target. This warhead reenters the atmosphere at a very high speed. During reentry the front end of the warhead or the nosecone becomes very hot. A boundary area of very hot air is formed adjacent to the reentering nosecone. At these high temperatures some very strange and unusual phenomena are suspected to occur. The normal atmospheric gases become very hot and ionized and lose some of their electrons and form what we call a plasma, which is an electrically active mixture of molecules, atoms, ions, and electrons. These hot gases can send out radiations of various types such as visible radiation, infrared radiation, and perhaps even radio waves. It may be possible to detect a warhead by the types of radiations which are emitted from this plasma in the boundary layer. In order to do this we must understand the fundamental physics, the interactions between the air and the nosecone material, as well as wave transmission and emission with a hot plasma boundary. Therefore, we are sponsoring research work of a fundamental nature in shock tubes and theoretical studies and experiments in spacial wind tunnels to give a better understanding of what goes on and what produces the various types of radiations.

ARPA is supporting the development of a special hypersonic blowdown tunnel which will be capable of going to Mach (as high as) XV for durations as long as perhaps 20 seconds. This is much longer in duration than conventional hypersonic tunnels and will permit the evaluation of reentry physical phenomena; i.e., the interaction of such waves, boundary layers, and materials. This work is being done at the Cornell Aeronautical Laboratory and promises to give air stagnation temperatures above 8000°F and perhaps as high as 14,000°F by using lightweight gases.

In addition to this laboratory and theoretical work, at our missile ranges, we are measuring emissions from objects flying through space and reentering the atmosphere in a broad spectrum of wavelength. This is done from airplanes and ships which are equipped with special radar receivers, infrared detectors, visible light measuring instruments and other types of

measuring or tracking equipment. These instruments and their carriers are indeed very expensive, nevertheless, they provide some of the best methods to actually measure what is emitted from a body flying through space and through the upper atmosphere.

One very interesting project being done at the Naval Research Laboratory and at the Army Ballistic Research Laboratory concerns the high-velocity impact of pellets with space vehicles. The tool being used is essentially a gun which employs highly compresed gas of low molecular weight for the expulsion of pellets. Electrical energy is added to heat this gas in order to achieve high velocities.

Applied Research

This type of effort is directed toward a better understanding of a specific phenomena which could be used in one of our assigned military projects. For example, the Advanced Research Projects Agency has under contract a number of different approaches to formulate better solid propellants. Chemists tell us that solid propellants can be improved in their present performances by something like 10 to 20%. This is sufficient to essentially double the payload capability of a missile like the MINUTEMAN or it is sufficient to make solid propellants suitable for various future space flight and missile missions. We have solicited the efforts of some of the country's best chemical organizations and people (in industry, universities, and Government laboratories) to formulate new compounds, tricky new mixtures of oxidizers and fuels, new chemical preparation processes. The new compounds are those which are particularly suitable for high-energy solid propellants. They usually contain either light metals (such as beryllium, boron or magnesium) or highly electronegative substances (such as fluorine, oxygen or perhaps even chlorine.)

We are contracting for a study to investigate the heat rejection mechanisms in space-borne radiators. This includes investigation of the effect of special surface coatings and the mechanism of condensing vapors in a vacuum, the evaluation of factors used in the selection of working fluids, and the effects of radiator geometry and orientation.

The Cornell Aeronautical Laboratory is investigating for us the fundamental physical effects necessary to build a high power microwave radar. This includes work on basic propagation phenomena within the atmosphere -- such as the noise created by aurora and cosmic dust, work on various specific components of such a radar and studies on the usefulness of this device. It is hoped to eventually achieve 50 megawatts of peak power for pulse lengths of 50 microseconds.

Development of Components

Our assigned fields of research require development of novel types of components in a variety of different forms. We have therefore undertaken to contract for the design and construction of ex-

perimental pieces of hardware, which, at a later date, can be made into lightweight flying units of proven basic principle. One example, the SATURN booster, consists of a cluster of 8 ballistic missile type engines and will quadruple our present booster launch capability.

Into this category of development fall various radar devices which have improved and increased range, improved resolution, and other special features. These radars will be suitable for the detection of satellites and unidentified missiles. This category also includes development of critical components in various plasma type propulsion systems, particularly those where either electrostatic fields or electromagnetic fields are used to accelerate the ionized working fluid or the plasma.

Another example concerns the study of a typical subsystem, namely, solar concentrators. These are optical systems that take the radiation energy from the sun and by means of mirrors and perhaps lenses, concentrate the sun's energy so as to heat various space-borne devices which can give useful vehicle power. The radiation energy from the sun received by our earth's satellites is relatively weak. Therefore, to achieve a power of 25 kilowatts, we would need approximately 2,000 square feet of mirror surface. The objective of this study is to determine the lightest weight, most compact and most economic method of concentrating the sun's energy.

System Feasibility Demonstration

In some of the more complicated satellite or ballistic missile defense systems, it is necessary to combine the various components into an experimental system to demonstrate that the various components are properly matched and that no additional technical problems will arise which may have been overlooked in the component developments.

For example, in a delayed repeater communication satellite the complete system contains several ground tracking stations, a number of ground receivers and transmitters, satellite-borne receivers, satellite-borne transmitters, satellite-borne power supplies, satellite-borne information storage devices such as tape recorders, special signaling devices which turn the space receivers and transmitters on and off, the booster and sustainer rocket stages, guidance systems, launching stations, and perhaps even satellite-borne orbital correction devices. All of these have to function in proper sequence, at the appropriate time, and in such a manner that one component will not prejudice the performance of another.

In order to assure ourselves that all of these components are compatible, it is necessary to perform experiments with the complete system. Very often these experiments are not made with the final system but with interim hardware that contains the basic concepts in principle but may not contain the final design versions.

System Studies

Complete military systems, or even some of their subsystems, are

extremely expensive. It is therefore necessary to select the chosen system carefully from all points of view; such as, performance, economics, technical feasibility, or the ability to perform (at a later date) some additional functions. In order to help with this selection and in order to eliminate work on other possible systems which may no longer be of interest, we conduct a number of systems studies, feasibility studies, optimization studies and economic evaluations. These studies are often carried on simultaneously with component development work.

We are also in the process of conducting studies comparing various types of space-borne power supply systems to determine which is best for various specific future applications. Studies of satellite communication systems, radar acquisition systems or data and decision making systems fall into this category.

How Unsolicited Proposals Should Be Prepared and Submitted

Proposals should be submitted in duplicate to the Director, Advanced Research Projects Agency, The Pentagon, Washington 25, D. C.

It is the desire of ARPA to utilize small business to the maximum extent possible, therefore, proposals from small business are particularly encouraged.

Before submitting an unsolicited proposal to ARPA, the proponent should make a thorough search of all technical reports, patents and other data pertaining to the subject in order to become thoroughly familiar with the state of the art.

No standard format exists for submission of proposals, however, they should contain the following information (Proposals should not normally exceed 25 pages in length):

*General statement requesting consideration of the proposal.
*A technical description of the proposed work, including a brief review of the scientific background and of work previously done in the field of the proposal.
*Statement of the objectives of the project.
*Technical approaches proposed.
*Special facilities and equipment required and available.
*Major phases and action milestones through which the project will progress with estimated dates for each.
*Estimated cost of the proposal, showing a breakdown of major cost categories.
*Names and background of principal scientists and engineers who will be used in the project.

To facilitate handling and evaluation of unsolicited proposals, it is recommended that a covering letter list the names of other government activities to which the proposals have been submitted.

Any information contained in a proposal which concerns a basic or major improvement and which is considered to be of a proprietary nature should be clearly identified. A differentiation should be made between proprietary data and patent data when one or both are contained in a proposal. (The Armed Services Procurement Regulations (ASPR), Section 9-201(b) gives the definition of proprietary data. These may be seen at the office of any contracting officer of the Department of Defense or they may be obtained from the Superintendent of Documents, Government Printing Office.) The government is not obligated for reimbursement of costs incurred in preparing and submitting proposals.

PUBLICATIONS CHECKLIST

( ) Research Relations between engineering educational instructions and industrial organizations are discussed in a new report designed to help businessmen interested in research. Discusses external and internal research agencies, operational agreements, details of research contracts and similar information. 38 pages. 25 cents. (Write Superintendent of Documents, Government Printing Office, Washington 25, D.C. for Small Business Management Series No. 23)

( ) Office of Naval Research, a new guide to the scientific information activities of the ONR covering ONR headquarters, Naval Research Laboratories and other navy research organizations. Single copies free. (Write Information Office, National Science Foundation, Washington 25, D.C. for ONR Science Information Guide)

( ) Missile Development and Space Sciences, covers the testimony of military and civilian experts on a variety of subjects in the general field of space research. No Index. 492 pages. Single copies free. (Write House Committee on Science and Astronautics, New House Office Bldg., Washington 25, D.C. for Hearings, Missile Development and Space Sciences)

( ) Satellite Communications, military and civilian testimony on plans for the use of satellites in communication relay operations. 122 pages. Single copies free. (Write House Committee on Science and Astronautics, New House Office Bldg., Washington 25, D.C. for Hearings, Satellites for World Communications)

( ) Ballistic Missile Re-Entry, a 1953 study just declassified on the motion and aerodynamic heating of ballistic missiles entering the earth's atmosphere at high supersonic speeds. Includes consideration of the means available to the designer for minimizing aerodynamic heating and similar subjects. 16 pages. Single copies free. (Write Research Information, NASA, 1520 H Street, N.W., Washington 25, D. C. for NACA Report 1381)

( ) Mine Explosions, a technical report on a new technique for determining the "explosion potential" of the atmosphere in a sealed area. Applies primarily to coal mines but may be of aid in other fields. Single copies free. (Write Bureau of Mines, Publications-Distribution Section, 4800 Forbes Avenue, Pittsburgh 13, Pa. for Information Circular 7901)

( ) Radiation Exposure, the new handbook covering the latest recommendations on maximum permissible internal exposure of the human body to radioisotopes in air and water. 95 pages, 35 cents. (Write Superintendent of Documents, Government Printing Office, Washington 25, D.C. for NBS Handbook 69)

( ) Ground Cushion Phenomenon, a staff report urging increased attention to this new form of transportation. 14 pages. Free. (Write House Committee on Science and Astronautics, New House Office Building, Washington 25, D.C. for Staff Report No. 10)